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TITLE – Compatibility of the Apollo Lunar Surface Experiment Package (ALSEP) and the Apollo MSFN.

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(NASA-CR-156516) COMPATIBILITY OF THE APOLLO LUNAR SURFACE EXPERIMENT PACKAGE (ALSEP) AND THE APOLLO MSFN (Bellcomm, Inc.) 5 p

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The compatibility of the command and telemetry formats of the Apollo Lunar Surface Experiments Package (ALSEP) with those of the Apollo space vehicle is investigated. A comparison is made between the proposed ALSEP telemetry and command formats and those being implemented for elements of the Apollo space vehicle. The possibility of making the ALSEP formats the same as existing Apollo formats is evaluated. It is concluded that requiring the command and telemetry formats used in ALSEP to be the same as those used in the Apollo systems is an undesirable design constraint.

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DATE: April 29, 1966

FROM: R. L. Selden

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TECHNICAL MEMORANDUM

Early in the development of the Apollo Lunar Surface Experiments Package (ALSEP), it was recognized that the communications used with the ALSEP should be compatible with the Apollo Manned Space Flight Network (MSFN). Accordingly, the choice of telemetry frequencies and command frequency for ALSEP was made so that they could be handled by the MSFN Unified S-band Stations. More recently, as a result of action items generated at ALSEP meetings on April 1 (at MSC), April 12 (at GSFC), and April 18 (at MSC), Bellcomm has evaluated the possibility of modifying the telemetry and up-data formats and signals proposed by the ALSEP contractor (Bendix Systems, Inc.) to be similar to those used by the CSM, LEM, or SIVB/IU. In particular, if the same formats were used, an appreciable savings would be obtained in the cost of software for the computers that process telemetry and command data at each Apollo MSFN site. The telemetry and command systems at each MSFN site are independent except for the telemetered indication of correct reception of commands and can generally be evaluated for ALSEP-Apollo commonality separately.

The telemetry characteristics of the CSM, LEM (low bit rate only) and presently proposed ALSEP telemetry systems are presented in Table I. The SIVB/IU telemetry uses only a high bit rate (72 Kbs) mode.

| | CSM | LEM | ALSEP |
|---|---|---|---|
| Bit Rate (bps) | 1600 | 1600 | 1060 |
| Frame Rate (fps) | 1 | 1 | 1 21/32 |
| Words per Frame | 200 | 200 | 64 |
| Frame Length (bits) | 1600 | 1600 | 640 |
| Word Length (bits) | 8 | 8 | 10 |
| Sync Word Length | 26 | 26 | 22 |
| Subcommutation Channels | None | None | 90 |

Table I - Telemetry Characteristics CSM, LEM, & ALSEP

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GSFC personnel stated at the meeting at GSFC on April 12, 1966, that in order to use existing Apollo software for the MSFN remote site telemetry computers, ALSEP would be required to provide the same bit rates, word lengths, frame lengths, and frame rates and similar subcommutation. From Table I it is obvious that a new program would be required to permit the MSFN stations to process the proposed ALSEP telemetry data.

After study it appears that changing the ALSEP telemetry format to be the same as one of the Apollo formats would degrade the ALSEP performance for the following reasons:

1) Increasing the bit rate to 1600 bps would degrade the telemetry performance margins by 1.8dB.

2) Subcommutation used in the ALSEP telemetry format would have to be deleted. Since the subcommutator in the ALSEP telemetry package provides a sample of all the housekeeping data and at a rate of approximately once per minute a format similar to the CSM or LEM would provide a sampling of these parameters of once per second which would be a wasteful redundant information transfer.

3) The contractor for the ALSEP equipment (Bendix Systems Division) states that a major redesign of the data processor would be required to switch to a compatible Apollo format and it would result in a three months schedule delay.

Up-Data Formats

The up-data formats proposed for ALSEP differs markedly from that used on any of the Apollo vehicles. The major differences are:

1) No sub-bit encoding,

2) No subcarrier is used for the up-data (the up-data signal that modulates the up-data subcarrier (70 Kc) in the Apollo USB system would directly modulate the S-band up-carrier in ALSEP).

3) Word structure and word lengths (format) are different in ALSEP than in the Apollo Space Vehicles. The requirement for up-data in ALSEP is quite similar to the Real Time Command (RTC) requirement for the Apollo space vehicles. A major difference is that a capability for 128 different commands need to be provided for ALSEP. This requires that the data word be at least seven

bits long for ALSEP whereas the Apollo command systems generally need no more than six bits. (According to Mr. T. Stuart of FSD/MSC, the Block II CSM will have a capability of transmitting up to 128 Real Time commands. However, this will be accomplished with two sequential commands instead of one).

The effects of making the Command System formats common between ALSEP and the Apollo CSM, LEM, or SIVB/IU are similar to the effects of using common telemetry formats. If ALSEP were required to change to an existing Apollo up-data format, the schedule, cost and performance (i.e., prime power consumption and reliability) of ALSEP would be affected. If the MSFN sites are required to use the presently proposed ALSEP up-data format a new program will be needed for the remote site command computer.

A ground rule for ALSEP operation is that an MSFN Station supporting ALSEP will not be required to support an Apollo mission at the same time. This implies that an ALSEP computer program can be a separate piece of software and not a part of the operational Apollo executive program. As separate programs, the ALSEP Command and Telemetry programs for the remote MSFN sites will not impact the operational Apollo programs in any way and would not have to be stored in the remote site computer memorys simultaneously with the operational Apollo programs. Instead they would be read into the memory of the remote site computers during the turnaround time (a minimum of 15 minutes between Apollo and ALSEP operation).

Even if the format of the ALSEP command system were made similar to one of the Apollo formats some additional programming both in general and on a mission to mission basis would be required. Examples of this type programming are general data housekeeping (package addresses, associated package sub-bit encoding etc.) and command verification. A good estimate of the time required and the cost to design these program changes is not available at this time. However personnel at both GSFC and MSC have indicated a significant effort will be required to generate a separate program for ALSEP if the formats are to be similar to Apollo formats. Additionally it would not take much more effort or time to provide a software system suitable for use with the proposed ALSEP formats.

In summary, the ALSEP command and telemetry requirements indicate that they cannot be fullfilled optimally when using existing Apollo formats. In the telemetry system, Apollo formats

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would add unneeded redundancy to the telemetered data and because of the bit rate increase required would degrade system performance by at least 1.8 dB. In the command system a significant computer programming effort would be required even when using an existing format. Additionally ALSEP performance (i.e., reliability and prime power consumption) would be degraded if command format commonality were required. For these reasons requiring the ALSEP telemetry and command formats to be the same as those used with the Apollo space vehicle is not an acceptable constraint.

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